Food for Fuel: The Price of Ethanol

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Abstract

Conversion of corn to ethanol in the US since 2005 has been a major cause of global food price increases during that time and has been shown to be ineffective in achieving US energy independence and reducing environmental impact. We make three key statements to enhance understanding and communication about ethanol production's impact on the food and fuel markets: (1) The amount of corn used to produce the ethanol in a gallon of regular gas would feed a person for a day, (2) The production of ethanol is so energy intensive that it uses only 20% less fossil fuel than gasoline, and (3) The cost of gas made with ethanol is actually higher per mile because ethanol reduces gasoline's energy per gallon.

Introduction

The US used over 45% of its 2011 corn crop to produce ethanol, up from under 15% before 2005 [1]–a rise dictated by federal mandate and promoted by federal subsidies. The drought in 2012 is leading to questions about whether using corn for fuel is reasonable while people go hungry due to a world food shortage. Here we provide a context for this discussion by addressing the following three questions: How much food goes into ethanol production? What is the net gain in energy from ethanol production after accounting for the fossil fuel energy used in the process? How does the use of ethanol affect gasoline prices?

1. Food used to make ethanol

How many people could be fed with the corn used for ethanol? In the US, the primary ethanol production input is field corn. While not typically eaten on the cob, field corn is used to make other food including breakfast cereal, corn flour or meal, corn sweetener, and corn oil. It serves both as food for people and feed for livestock–which subsequently becomes food for people in the form of poultry, pork, and beef.

A bushel of field corn can be used to produce about 2.77 gallons of ethanol [2–6]. A bushel of field corn weighs 56 pounds, each pound containing about 1,550 Calories [7, 8]. Therefore, it takes about 31,300 Calories of field corn to produce one gallon of ethanol. Regular gasoline (E10) typically contains 10% ethanol by volume (averaging 9.6% nationally in 2011 [9]). Therefore, about 3,000 Calories of corn energy is used to produce each gallon of regular gas.

The suggested daily food energy intake is 2,100 Calories per person [10]. A single gallon of regular gas contains more than enough food energy to feed a person for one day. More precisely, every gallon would feed 1.4 people for a day or one person for 1.4 days.

It is often pointed out that a portion of the corn energy does not end up in the ethanol, but instead in by-products subsequently fed to animals, called distillers grains, which may account for up to 31% of the corn by weight [11]. The actual amount is often less than 31% and in 2011 was 23% overall [12]. The by-products are not used for food, and their nutritional content limits their use for animal feed [13]. Even after removing 23% or 31% of its food energy, a gallon of regular gas still contains more than enough to feed a person for

a day.

What is the equivalent amount of sweet ("on the cob") corn in regular gas? The energy in sweet corn is 485 Calories per pound [14, 15], and there are about 0.2-0.25 edible pounds on each ear of corn [14]. In a gallon of regular gas there is food energy equivalent to 28 ears of sweet corn, while just 19 ears of sweet corn would satisfy a person's daily energy requirement.

An average 16 gallon tank of gas contains ethanol from enough corn to feed 22 people for a day, or one person for over three weeks.

The total amount of ethanol produced in the US in 2011 was 13.95 billion gallons [9], enough to feed 570 million people that year.

2. Energy Balance of Corn Ethanol

When weighing the costs and benefits of corn ethanol, it is important to consider the net energy yield: how much more energy we get from a gallon of ethanol than is used to make that gallon. Fossil fuel energy is required to produce and transport fertilizers and pesticides, irrigate farmland, and plant and harvest the corn (not including the solar energy involved). Additional energy is required to transport the corn from the field to the ethanol plants and power the conversion process.

The most optimistic assessments claim around 1.3 units of energy are produced for each unit of energy input [16]. However, this estimate uses data from the best corn-growing conditions (requiring relatively low costs to grow), and considers the best processing conditions (including the highest possible distiller grain outputs as well). The average of the net energy yield across all corn-growing regions has been found to be 1.01 [17]. This means that the same amount of fossil fuel energy goes into making a gallon of ethanol as can be obtained by using that ethanol in a car.

Gasoline also requires energy to make. However, the ratio of output to processing energy for petroleum is about 5 to 1 [16]. This means that an extra 20% fossil fuel is used for each gallon of gasoline that is burned in a car [18–20].

Thus we need 1.0 fossil fuel BTUs on average to produce 1.0 ethanol BTUs of fuel energy. We need 1.2 fossil fuel BTUs to produce 1.0 fossil fuel BTUs of fuel energy. By choosing ethanol instead of gasoline, we save about 0.2 fossil fuel BTUs for each BTU used. This is

the only gain from ethanol after loss of its food value. The amount of fossil fuel saved by using ethanol is only about 0.2% of the US energy requirements [21, 22].

3. Gasoline Price Benefit of Corn Ethanol

While it has been claimed that ethanol has reduced the price of gasoline [23, 24], what is reported is the cost per gallon, but what is relevant is the cost per mile driven. Ethanol has less energy per gallon than gasoline. A gallon of gasoline contains about 125,000 BTUs while ethanol contains about 84,300 BTUs [25], or about 67% that of gasoline. When the price of ethanol is between 67% and 100% of the price of gasoline, which it often is, ethanol is cheaper by volume but more expensive by energy. The cost per gallon of gasoline with ethanol is lower, but it is as if the gasoline is watered down—the cost per mile driven is higher.

This means that in addition to the government subsidy of $20 billion from 2005-2011 [26], every gallon of gasoline with ethanol bought is an extra subsidy from consumers to the ethanol producers.

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